MEDIATION EFFECT OF LEAN: A BIDIRECTIONAL SYNERGETIC RELATIONSHIP WITH SCM FOR HIGHER OPERATIONAL PERFORMANCE☆

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ABSTRACT
Competitive plants focus their efforts on reducing manufacturing costs and waste along their production chains. Hence, manufacturing programs with important practices and methodologies such as lean, JIT, TPM, and Kaizen have been embraced. However, an empirical investigation of simultaneous use of several manufacturing programs representing multiple facets of lean is lacking in the literature. Various studies have found that some supply chain management practices are bi-directionally related to lean, but its holistic measurement in relation to supply chain management is still lacking. Thus, this paper provides an evidence of mediation effect of lean from high performance manufacturing (HPM) project perspective in relation to supply chain management.

Keywords: lean supply chain, supply chain management, operational performance

INTRODUCTION
As a result of increasing global business competition, competitive plants are looking ways to gain competitive advantage (Ugochukwu et al., 2012) and focus their efforts on reducing costs and waste along their production chains. Manufacturing programs with important practices and methodologies such as lean (L), Just in Time (JIT), Total Productive Maintenance (TPM), Enterprise Resource Planning (ERP), Total Quality Management (TQM) and Kaizen have been embraced (Demeter and Matyusz, 2011). Thus, a key perspective in reducing costs and waste is the relationship between lean and Supply Chain Management (SCM) to improve the company's operational performance (OP) (Flynn et al., 1999). Although, lean had been used since the 19th century in Japan with TPM and JIT (Ohno, 1998), SCM did not gain currency until toward the

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end of last century and beginning of the current century, making it a relatively recent management buzzword, which is now regularly used by Production & Operation Managements (P&OM) managers (Luque and Medina, 2009).

Due to globalization, competitiveness, contingencies, and links, improvement initiative of lean has gone beyond its core JIT. Empirical tests show the influence along SCM of main manufacturing programs (i.e. sets of manufactuing practices) such as TQM, TPM, and others manufacturing programs (Lamming, 2006). In the literature of SCM, the overwhelming part of it shows some common practices that influence operational performance. Nonetheless, they do not directly include research that measures the relationships of factors such as agreed vision and goals, agreed supply chain leadership, JIT/lean capability, cross-functional teams, logistics integration and mediation effect (Naylor et al.,1999; Suhong and Ragu-Nathan, 2006). SCM is commonly referred to the simultaneous integration of customer requirements, internal processes, and upstream supplier performance (Handfield and Nichols, 1998). Regardless L impact in SCM relationship, research usually shows L to be associated with high performance around world class-manufacturing (Sakakibara et al., 1997). SCM integrates supply chain, suppliers, manufacturers, and customers to achieve and improve, financial and growth objectives.

SCM initiatives alone cannot improve profitability and market share. It is necessary to link different practices or methodologies to achieve it (Tan et al., 1999). The most commonly cited benefits related to lean practices are; improvement in labor productivity and quality, along with reduction in customer lead time, cycle time, and manufacturing costs (Shah and Ward, 2003). Many researchers argue that a lean production system is an integrated manufacturing system requiring implementation of a diverse set of manufacturing practices (e.g. Womack and Jones, 1996). Empirical studies focusing on the impact of lean implementation on operational performance are constrained to one or two facets of lean, which are often JIT or TQM (Demeter and Matyusz, 2011) and improved operational performance associated with JIT practices (Sakakibara et al., 1997).

Empirical evidence supports the idea that lean contributes to improve OP. Lean bundles contribute to operational performance of companies, and explain about 23% of the variation of this, after accounting for industries effect and contextual factors (Shah and Ward, 2003). But the literature related expressed that the financial performance effects of lean production are mixed (Fullerton and Wempe, 2009). Besides, the literature shows that lean is a multi-dimensional approach that encompasses a wide variety of management practices. Lean can work synergistically to a streamlined, high quality system that manufactures finished products at the pace of customers demand with little to no waste, while improving processes and performance (Shah and Ward, 2003).

In this regard, an empirical investigation of simultaneous use of several manufacturing programs, standing for multiple facets of lean, is lacking in the literature. We attempt to discuss this clear gap in the literature by examining the performance implications through the practices considered in lean High Performance Manufacturing (HPM) project after controlling the effects assigned to industry differences and contextual factors (Shah and Ward, 2003). Additionally, the literature does not show any conclusive evidence of lean mediation (partial or full). Other authors revealed that lean practice application still occurs in a fragmented way, disregarding the systemic linkage that is essential to lean manufacturing. Forty-one articles suggest a positive effect of lean practices in at least one operational, financial, and/or environmental performance metric. Nevertheless, five studies show that some lean practices have a negative effect on operational or financial performance (Negrao et al., 2017). In the latest global

worldwide conference for production and operation management (P&OM: co-organized every four years by three leading academic associations which represent the operations management discipline in three regions: EurOMA, JOMSA and POMS[*]), focusing on research about lean mediation models from HPM perspective, of 47 papers related to SCM and 26 related to lean, just four of them were topics related to mediation along SCM and Lean, and eight related to moderation between these practices. Therefore, it can be useful in describing another way to use lean as a dynamic effect between SCM and OP through HPM perspective (Machuca et al., 2016).

Consequently, the aim of this paper is to show some evidence of an holistic lean program mediating the relationship between SCM and OP from HPM project perspective. Direct and indirect effects are analyzed in both ways, from SCM to OP and OP to SCM. To achieve the goal, a background is next presented. Thereafter, the research methodology is explained showing some details on sample, methods, and statistical techniques to measure mediation between SCM, L and OP. We show assessments considered in the proposed model. Additionally, in the analysis and results section, we present mediation level and coefficients between constructs considered in this research. Finally, the concluding section expresses limitations and future research.

BACKGROUND AND HYPOTHESES

The lean concept originates with Toyota and supports companies that achieve more with less; human effort, time and cost. Lean was popularized by Womack et al. (1990) with the book called "The Machine that Changed the World: The Story of Lean Production." Today this philosophy is applied across various industry sectors (Ugochukwu et al., 2012). Although there is no accepted general definition, Shah and Ward (2003) describe lean as a management philosophy that is concerned with identification and elimination of waste within and beyond organizations product value chain (Shah and Ward, 2003).

Womack and Jones (1996) articulate comprehensive business logic on lean management, which is called lean thinking or lean principles. The five lean principles by Womack and Jones include (Womack and Jones, 1996): Specify value from the end customer view, map value streams, establish flow, let the customer pull the products, and strive for perfection. Each lean principle is implemented by applying certain practices. On the other hand, supply chain can be defined as a network of facilities and activities, which perform product development, procurement of materials between facilities, manufacturing, and distribution of goods to customers (Beamon, 1998).

SCM includes suppliers, manufactures, focal organization, distributors and end customers (Ugochukwu et al., 2012). SCM has not only been used to explain logistic activities, planning and control of materials and information, but also to link processes with performance through vertical integration (Chen and Paulraj, 2004). This helps manufacturing companies develop capabilities in order to achieve higher performance and competitive advantage (Schroeder, 2002). The linkage of lean and SCM is based on the implementation of lean in the supply chain to achieve competitive advantage, considering lean as a very basis of supply chain management (Agus and Hajinoor, 2012). Many researchers consider lean to make supply chain management more effective, describing lean as a close alignment from raw material to customer through cooperation, adopting this philosophy to integrate their supply chain members and activities

[*] The conference ranking based upon the first author affiliation index (FAAI) showed that POMS was the best conference on production and operation management, followed by the Academy of Management, EurOMA and OSCM (Steenhuis and Bruijin, 2010).

(Ugochukwu et al., 2012). The characteristics and linkage of lean along with supply chain management are; integrated supply chain members, effective communication, and information sharing, effective demand management, end customer focus, continuous improvement, low inventories and few suppliers, and continuous flow and long-term contracts between supply chain members, integrated supply chain members, effective demand management (demand pull), and effective communication and information (Ugochukwu et al., 2012).

Furthermore, in the literature the following aspects were established as practical implication of the relationship between L and SCM; low inventories, customer satisfaction, optimized efficiency, high quality, reduced cost and improved delivery regarding time, quantity and quality specifications and high flexibility. These, have directly impact on operational performance (Ugochukwu et al., 2012). In this implication, the SCM processes have caused a direct positive impact on company´s performance, which are called "effects" (Salvador et al., 2001). This performance may be measured along with another four generic dimensions: 1) low cost, 2) quality, 3) delivery and 4) flexibility (Ahmad and Schroeder, 2002).

In the processes of SCM impacting OP, there exist different operations paths that may be used to improve companies' performance (Yang and Hong, 2011). One of the best ways is to apply lean manufacturing (lean supply chain), in such a way that permits doing more with less in terms of: human effort, equipment, time, and space, while coming closer to providing customers with exactly what they want (Watson et al., 2002). Companies do not always know or can measure the real impact of supplies reductions, when they apply lean along SCM (Phan and Abdallah, 2011). Therefore, to have an estimate of the real impact in both ways (direct and indirect effect), cross sectional mediation may be one possible effective option, measuring the total effect between to variables through the addition of direct and indirect effect (Kenny, 2004). All this, when data does not have high variation that would yield the same parameter estimates in different moments in the time (Hayes, 2013). This may be done following different steps to test it, as proposed by Judd and Kenny (1981).

In response, we use a representative construct of lean and SCM dimensions in our research that are measured through construct (scales) validated by four rounds of data collected from worldwide companies as part of the international High Performance Manufacturing project (HPM) (Schroeder and Flynn, 2001). Moreover, the present study analyzes SCM, L, and OP construct that are used to measure the competitiveness in HPM environments. In support of this, previous works of representative authors, which addressed supply chain management, plant performance and cross-sectional mediation were used. These works show interrelationships between the constructs in question, but it is very hard to find the papers on the bidirectional relationship between SCM, OP and L, through mediation.

Based on the discussions above, the research question guiding this paper is: does holistic lean program mediates relationships between SCM and OP? Hence, elements of a bidirectional synergetic relationship of lean with SCM for higher OP are identified. From this, research model in Figure 1, proposes a mediation process of lean (l) along Supply chain management (SCM) and Performance (OP). All of them are reflective construct (Peng and Lai, 2012), in pursuit of understanding the mediation level (indirect effect). Thus, Structural Equation Model (SEM) was used to find partial or full mediation along SCM and OP relationship. Subsequent hypotheses are set out:

H1. An holistic lean from HPM project perspective, mediates the relationship between SCM and OP.

H2. There is evidence of a bidirectional synergetic relationship of lean from HPM project perspective, along SCM and OP.

METHODOLOGY

The empirical evidence which we will use to test propositions was taken from the fourth round of surveys (2016) of the international High Performance Manufacturing project (HPM). Surveyed plants had a minimum of 100 workers. Sample sizes are an important consideration in SEM since it can affect the reliability of parameter estimates, model fit, and the statistical power of SEM (Peng and Lai, 2012). The international sample, from auto suppliers, electronics and machinery industries, was 309 plants from 14 countries in three continents (America, Asia and Europe, see Table 1). Practices of SCM, lean from HPM perspective (mediator variable) and OP dimensions were measured by Likert scale.

Table 1- Demographic data table of survey

COUNTRIES / INDUSTRIES	AUS	BRA	CHN	ESP	FIN	GER	ISR	ITA	JPN	KOR	SWE	TWN	UK	VIE	TOTAL
ELECTRONICS	1	5	10	8	6	6	21	7	6	8	4	19	4	10	**115**
MACHINERY	6	7	17	7	6	13	5	17	7	5	4	10	5	7	**116**
AUTOMOTIVE / CAR SUPPLY	1	9	3	10	5	9		5	9	13	1	1	4	8	**78**
TOTAL	**8**	**21**	**30**	**25**	**17**	**28**	**26**	**29**	**22**	**26**	**9**	**30**	**13**	**25**	**309**

SCM, L and OP scales were checked for content validity and reliability. To achieve empirical research objectives, we used cross-sectional mediation (Maxwell and Cole, 2011) using SEM based on approach to Partial Least Squares (PLS). Over time, structural equation modeling (SEM) has been widely adopted in social and psychological research. Operations management (OM) researchers have also used SEM largely (Peng and Lai, 2012). The use of structural equation modelling (SEM) implies that one or more models may be fit to the same covariance matrix. Statistically appraising the fit of a model to the covariance matrix is accomplished using a test referenced against the X^2 distribution, arguing discrepancy between model-implied covariances and actual observed sample covariances (Barrett, 2007).

Method: the conceptual model

This paper intends to demonstrate that SCM can improve performance through lean mediation, based on its improvement in terms of efficiency, competitive advantage and organizational performance. The mediation occurs when a variable (independent variable) affects another variable (dependent variable). The third construct (OP) was composed by seven competitive performance elements from HPM survey wholly or partially via its effect on another variable (Mediator variable) (Maxwell and Cole, 2011).

These are important in competitiveness settings and in other operations and supply settings characterized by lean mediation. From HPM data, we intend to demonstrate evidence of full or partial cross-sectional mediation, showing a bidirectional synergetic relationship between both elements toward higher performance.

In addition, this empirical research shows all paths between three constructs that are expected to be significant or not (variables to improve). The elements of the three considered variables in this research are derived from the component of these variables present in HPM project. In our research model, each latent construct (unobservable) compromises a number of variables.

Hence, the SCM construct considers: S1 (SCO Top Management Support (Suppliers)), S2 (Strategic Implications of SCM), S3 (Supplier Lead Time), S4 (Supply Base Reduction), S5

(Supply Chain Planning), S6 (Supplier Development), S7 (Supply Chain Evaluation and Performance Assessment).

The second construct (L), was composed by; L1 (equipment layout), L2 (kanban), L3 (small lot sizes), L4 (top management leadership for quality), L5 (supply chain quality focus), L6 (multi-function employees), L7 (modularization of products).

The third construct (OP) was composed by P1 (Unit cost of manufacturing), P2 (Conformance to product specifications), P3 (On time delivery performance), P4 (Fast delivery), P5 (Flexibility to change product mix), P6 (Flexibility to change volume), P7 (Inventory turnover).

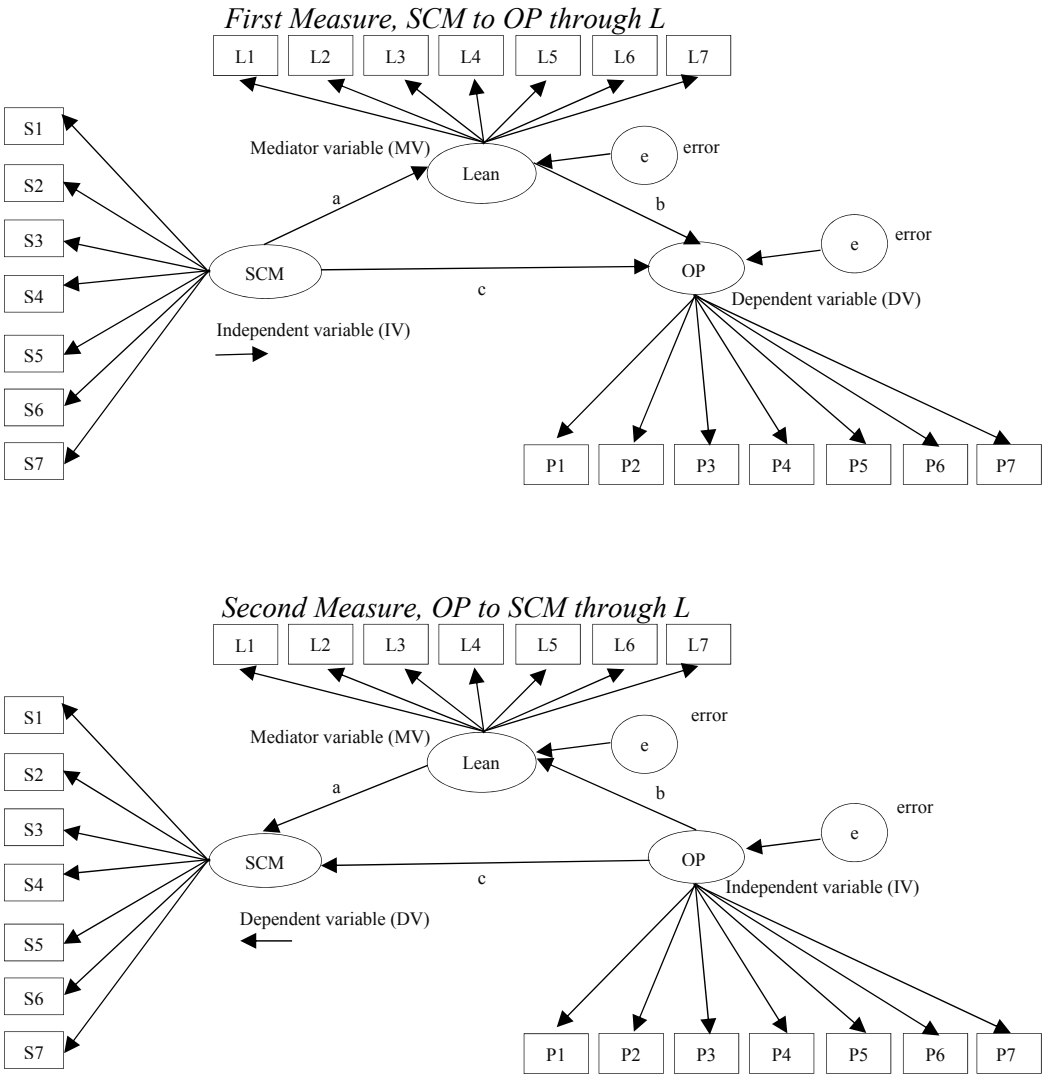

Figure 1 - Framework pointing out the hypothesis (Research Model)

The variables selection of each construct of SCM, L and OP was derivated of HPM project perspective. Through model in Figure 1, the research measures latent variable over construct (X, M, Y) which corresponds to SCM, L and OP, respectively, reviewing and comparing the existence of statistical significance after adding a lean as a mediator between SCM and OP (Sign.= 0.5, $p<0.05$, this means full mediation). As well, identification of lean main indicators through HPM scale, that do not have significant correlation and are affecting in both ways, from

SCM to L and from L to OP, it will call partial mediation (correlation values less than 0.5 with an acceptable level of significance). We expect that we find significant correlations in all constructs (values greater than 0.5 with significant level, lower than 0.05 between constructs SCM and L, and OP) (Grunberg, 2006). The expected result was measured using the following four equations:

$$M_{it+1} = mM_{it} + aX_{it} + \varepsilon_{Mit+1} \text{ (Mediation)} \quad (1)$$

$$Y_{it+1} = yY_{it} + bM_{it} + cX_{it} + \varepsilon_{Mit+1} \text{ (Direct effect)} \quad (2)$$

$$Y_{it+2} = yY_{it+1} + bM_{it+1} + cX_{it} + \varepsilon_{Mit+2} \text{ (Indirect effect)} \quad (3)$$

$$c' = \frac{(cx+b\rho X_t M_t)(\rho X_t X_{t-1} - \rho M_t M_{t-1}) + cm(1-xy)(\mathrm{x} - \mathrm{m}\rho^2 X_t M_t - ax\rho X_t M_t))}{(1-xy)(1-\rho^2 X_t M_t)(1-my)} \quad (4)$$

From equation *1-4, X (SCM), M (L) and Y (OP)* have been standardized (Maxwell and Cole, 2011). In bidirectional relationship, the position of independent variable is assumed by dependent variable (SCM will be OP and vice versa). Where $M_{it+1} = mM_{it} + aX_{it} + \varepsilon_{Mit+1}$ is the score for individual *i* on variable *M,* at time *t+1*, M_{it} is the score for individual *i* on variable *M* at the previous time point *t*, X_{it} is the score for individual *i* on variable *X* at time *t*, and $M_{it+1} = mM_{it} + aX_{it} + \varepsilon_{Mit+1}$ is an error term reflecting other influences on *M*. This also implies that *m, a, b, y*, and *c* are standardized coefficients. We assumed that all variables were latent variables.

At the same time (equations 1-2) the indirect effect of *X* on *Y* takes two units of time, one for *X* to influence *M* and another for *M* to influence *Y*. If the indirect effect takes two units of time, an argument could be made for expecting the direct effect to take two units as well. These derivations (equations 3-4) assume that (Maxwell and Cole, 2011):

(a) *X* may have a direct effect and an indirect effect on *Y*,
(b) the direct effect of *X* on *Y* occurs over two units of time,
(c) the path coefficients *a, b, x, m, y,* and *c*[†] are invariant over time and
(d) the system has reached equilibrium so that the cross-sectional correlations among *X, M,* and *Y* do not depend on the time of measurement.

ANALYSIS AND RESULTS

Empirical assessment

The research model is presented in Figure1, in which L, SCM and OP is modeled as a reflective construct. We use data from the fourth round of High-Performance Manufacturing (HPM) project to test the research model (Schroeder and Flynn, 2001). The sample size was 309, and the constructs and variables in question are presented in Table 2.

Mediation test was constructed by the correlation of three HPM constructs (SCM, L and OP). Stata and AMOS software were used to estimate our research model. The item scale (construct), variable, indicator label, weight (R), Composite reliability and communality (AVE) are shown in Table 2. All item loadings are greater than 0.50 and significant at the 0.001 level, showing convergent validity at the indicator level (Peng and Lai, 2012), with acceptable reliability,

[†] More explanations about equations 3 and 4 see Maxwell and Cole paper titled "Bias in Cross-Sectional Analyses of Longitudinal Mediation: Partial and Complete Mediation Under an Autoregressive Model"

greater than 0.70 (Nunnally, 1967).

We use promax rotation to calculate factor reductions loadings, due to it is both faster than a direct oblimin rotation, as well as useful for large data sets. Model was checked to ensure the results were acceptable and consistent with underlying theory (Lin et al., 2005). Moreover, AVE values are greater than 0.50, showing convergent validity at the construct level. With respect to research model quality, we calculated the Goodness of Fit (GoF) through Wetzels et al. (2009) formula:

$$GoF = (Average\ AVE) * (Average\ R - Squared) = (0.576) * (0.671) = 0.39 \quad (5)$$

Additionally, Wetzels et al. (2009) suggested the subsequent thresholds to GoF; small=0.1, medium=0.25 and large=0.36. On the other hand, the use of reduction factors, allowed determinate homogeneity variables groups from data set, based on correlation with each other, being independent and making known convergent validity at the construct level (Polo, 2009). Regarding the reduction factor it was examined KMO and Bartlett test (KMO=0.77 and sig. 0.000), total variance, correlations, patron matrix, structure matrix and factorial correlation matrix.

Table 2 - Measurement properties of reflective constructs

Scale	Variable	Description	Weight	Composite reliability	Communality (AVE)
SCM	S6	Supplier development	0.70	0.90	0.81
	S7	Supply chain evaluation and performance assessment	0.52		
	S4	Supply base reduction	0.38		
	S3	Supply lead tine	0.31		
	S5	Supply chain planning	0.35		
Lean	L5	Multi-function employees	0.49	0.76	0.57
	L4	Supply chain quality focus	0.47		
	L1	Equipment layout	0.31		
OP	P1	Unit cost of manufacturing	0.93	0.80	0.64
	P3	On time delivery performance	0.97		
	P2	Conformance to product specifications	0.38		
	P5	Flexibility to change product mix	0.87		
	P6	Flexibility to change volume	0.81		

The following steps were performed to estimate the mediation effect: 1. Measured the total effect between SCM and OP (Figure 2), 2. a (coefficient value from SCM to lean) and b (coefficient value from lean to OP) values were estimated (Figure 3), 3. Direct and indirect effect of SCM on OP through L, were calculated.

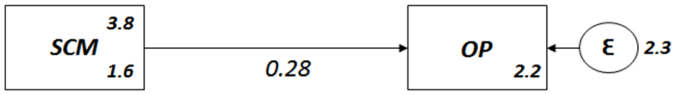

Figure 2 - Direct effect measurement between SCM and OP

After the factor reduction as the first step, the direct effect was calculated through latent variables relationship between SCM and OP with the aim to find significant effect for *c* coefficient, referred like a total effect (Figure. 2). The application of Equation 2 results the measurement of the coefficient between SCM and OP. SCM box shows that the mean was 3.78. and Standard mean value of 3.03 with 1.56 of variance. The Figure 2 shows a positive and significant total effect of SCM on OP, the coefficient value was 0.28, OP has a value of 2.2 of intercept constant with a variance value of 2.3. Also, Table 3 presents direct effect estimates between SCM and OP. The results show a significant coefficient and express direct effect along with two latent variables (unobservable) (coefficient = 0.28 and sig. 0.02). This shows an influence on SCM in OP. The LR test of model in function of saturated showed a chi2 (0):0.00. It is seen from data analysis, all but our research constructs are with Cronbach's a larger than 0.75.

Table 3 - Data of direct effect measurement between research variables

	Coef.	OIM/ Std. Err.	Z	P> |z|	[95% Conf. Interval]	
Structural performance <-						
SCM	0.2775767	0.0696388	3.99	0.022	0.1410871	0.4140663
_Cons	2.16437	0.2771998	7.81	0		2.707672
Variance						
e. performance	2.332815	0.1876791			1.992505	2.731247

LR test of model vs. saturated: chi2(0) = 0.00, Prob>chi2=0.00

Furthermore, we introduced lean construct as a mediator along with SCM and OP. The estimated result shows the existence of partial mediation. Likewise, the coefficient correlation between SCM and OP decreased, but stays significant. For mediation measurement, it is necessary to compare the coefficient between SCM and OP before and after the mediation processes. In response, Figure 2 shows the first correlation measure that was 0.28 with a significant level less than p=0.022.

Then, when lean construct mediates SCM and OP relationship, correlation between both is reduced to 0.19 with a significant level (p=0.022). Both results were compared to determine an evidence of partial mediation of this construct, due to a direct effect reduction between SCM and OP such as mediation result (Figure 3). The same effect is shown when relation is developed considering OP as an independent variable. Table 4 gives more results about mediation, like coefficient, OIM and Standard error, Z value and confidence intervals.

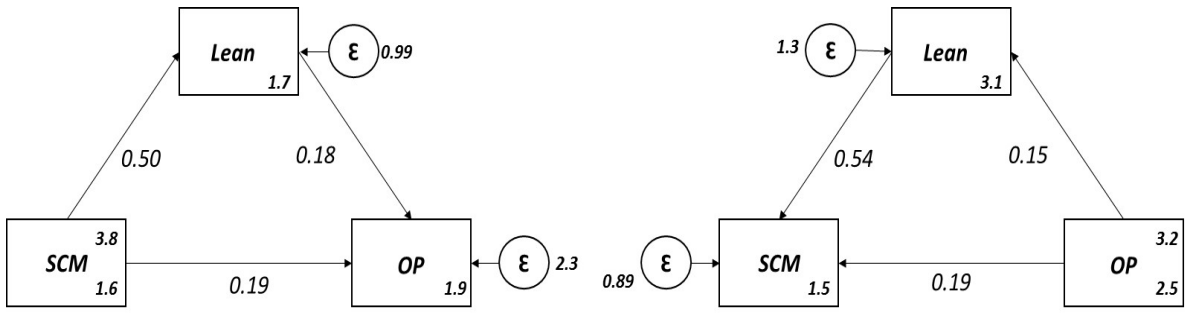

Figure 3 - Mediation effect of lean between SCM and OP relationship (Bidirectional)

Table 4 - Mediation Results from SCM to lean

	Coef.	OIM/ Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Structural performance <-						
lean	0.1812	0.0866	2.0900	0.0360	0.0115	0.351
SCM	0.1868	0.0816	2.2900	0.0220	0.0269	0.3468
_Cons	1.8522	0.3131	5.9200	0.0000	1.2385	2.4658
lean <-						
SCM	0.5006	0.0454	11.0200	0.0000	0.4116	0.5896
_Cons	1.7226	0.1808	9.5300	0.0000	1.3683	2.0769
Variance						
e. performance	2.3002	0.1851			1.9647	2.6931
e. lean	0.9923	0.0798			0.8475	1.1618

LR test of model vs. saturated: chi2(0) = 0.00, Prob>chi2=0.00

The regression coefficient of model from SCM to L, a, is 0.501 and that from L to OP, b, is 0.181. The path estimation from SCM to OP, c', is 0.187. All results were significant. The OP variance value was 2.3, and lean variance value was 0.99 (as in Figure 3). Table 5 shows the summary result of standardized and regression weights of bidirectional mediation. Similar results are obtained from bidirectional measurement. The regression weight of model from OP to L, a, is 0.15, and that from L to SCM, b, is 0.54. Moreover, the path estimation from OP to SCM, c', is 0.19, and all outcomes are significant. The SCM and lean variance values are 0.89 and 1.33, respectively. The total effect is c'+a*b, the direct effect is ***c'*** and the indirect effect c, is a*b. If the direct effect reduces but still being significant, indicate that exist partial mediation.

Table 5 - Standardized and Regression Weights: (Group number 1 - Default model)

Paths	Estimate	Variance	Paths	Estimate	Variance
lean <- SCM	0.501	2.3	**SCM <- lean**	0.539	0.89
OP <- lean	0.181	0.99	**lean <- OP**	0.149	1.33
OP <- SCM	0.187		**SCM <- OP**	0.182	

Table 5 shows that L mediates bidirectional relationship of SCM and OP. The values were consistent with significant level ($p<0.05$). Consequently, we can assume that lean not only improve operations efficiency, but its bi-directional relationship allows linkages between suppliers and decides who guides the customer relationship. Therefore, through obtained result by SEM and mediation analysis, we conclude that H_1 is accepted. There is evidence that lean from HPM project perspective mediates the relationship between SCM and OP (Partial mediation). Furthermore, H_2 is accepted; there is evidence of a bidirectional synergetic relationship of lean from HPM project perspective, along SCM and OP.

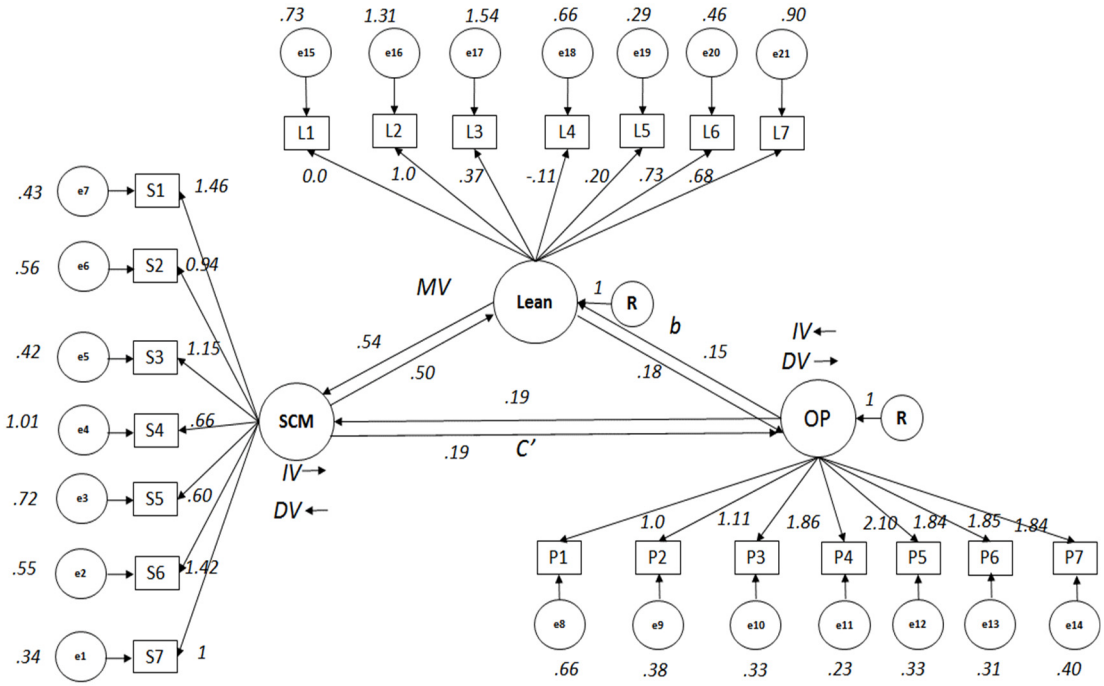

Figure 4 - Summary of findings

Hence, there are elements of a bidirectional synergetic relationship between L and SCM that increase OP, based on statistic result show in Figures 3 and 4. In both ways the coefficient between SCM and OP is reduced when L mediate the relationship.

In the relationship in which SCM was the independent variable, coefficient value from SCM to OP was reduced when L intervened. Similar effect was obtained when OP becomes independent variable and L mediates relationship between OP and SCM, by showing, in both directions, a reduction of direct effect called partial mediation. Also, evidence that ab is different from zero is consistent with mediation:

a*b (first measure) = indirect effect 0.5 * 0.18 = 0.09 (6)

a*b (second measure) = indirect effect 0.54 * 0.15= 0.081. (7)

RMSEA model was 0.0148, CFI = 0.949 and p value less than 0.05, confirming bidirectional relationship in these constructs.

Table 6 shows the trend with respect average of results obtained from plants under study. This indicates that both SCM and L have a mean that tends strongly toward agreement, supporting the evidence of mediation effect. While competitive performance depends on other variables not only on the previous two. Likewise, there is data in the SCM below the average of responses of L. Also, trends shown in Table 6, allow to show the possible deviations and variability in the responses of each company, supporting the evidence of partial mediation effect.

Table 6 - Trends of Scale results Mean of questionaries' on analysis of 309 plants*

Scale	Question	Less agree	Medium Agree		More Agree	
		1	2	3	4	5
OP		Poor, much worse than global competitors	Somewhat below global competitors	Average	Somewhat better than global competitors	Superior, much better than global competitors
P1	Unit cost of manufacturing			3		
P2	Conformance to product specifications			3		
P3	On time delivery performance			3		
P4	Fast delivery			3		
P5	Flexibility to change product mix			3		
P6	Flexibility to change volume			3		
P7	Inventory turnover			3		
Lean		Strongly disagree				Strongly Agree
L1	We have laid out the shop floor so that processes and machines are in close proximity to each other.				4	
L2	Suppliers fill our kanban containers, rather than filling purchase orders.		2			
L3	We have large lot sizes in our plant.			3		
L4	All major department heads within the plant accept their responsibility for quality.				4	
L5	We strive to establish long-term relationships with suppliers.				4	
L6	Our employees receive training to perform multiple tasks.				4	
L7	When we make two products that differ by only a specific feature, they generally require only one different subassembly/component.			3		
SCM		Strongly disagree				Strongly Agree
S1	Relationships with our suppliers are considered to be of critical importance to our plant's top managers.				4	
S2	We view the reduction of process lead time (cycle time) to reduce in-process inventory as a key to effective supply chain management.			3		
S3	We seek short lead times in the design of our supply chains.				4	
S4	We rely on a small number of high quality suppliers.(Is this an item from an HPM scale?)			3		
S5	We actively plan supply chain activities.			3		
S6	We provide our suppliers with sufficient technical assistance.			3		
S7	Conformance with specifications				4	

Table 7 - Summary of results of the structural model

Path	Estimate	S.E.	C.R.	P	Label	Description
L--S	0.501	0.045	11.004	***	par_14	SCM to Lean
P--S	0.1868	0.087	2.089	0.037	par_1	SCM to OP
P--L	0.1812	0.082	2.285	0.022	par_15	Lean to OP
S7--S	1					S7--SCM
S6--S	1.416	0.263	5.39	***	par_2	S6--SCM
S5--S	0.605	0.21	2.873	0.004	par_3	S5--SCM
S4--S	0.663	0.246	2.69	0.007	par_4	S4--SCM
S3--S	1.146	0.219	5.22	***	par_5	S3--SCM
S2--S	0.838	0.207	4.042	***	par_6	S2--SCM
S1--S	1.462	0.258	5.67	***	par_7	S1--SCM
P1--P	1					P1--OP
P2--P	1.106	0.237	4.656	***	par_8	P2--OP
P3--P	1.86	0.353	5.272	***	par_9	P3--OP
P4--P	2.097	0.387	5.419	***	par_10	P4--OP
P5--P	1.836	0.349	5.266	***	par_11	P5--OP
P6--P	1.853	0.35	5.288	***	par_12	P6--OP
P7--P	1.639	0.322	5.098	***	par_13	P7--OP
L1--L	1					L1--Lean
L2--L	0.372	0.438	0.848	0.396	par_16	L2--Lean
L3--L	-0.108	0.459	-0.236	0.814	par_17	L3--Lean
L4--L	2.012	0.706	2.851	0.004	par_18	L4--Lean
L5--L	1.727	0.584	2.957	0.003	par_19	L5--Lean
L6--L	1.372	0.502	2.732	0.006	par_20	L6--Lean
L7--L	0.68	0.411	1.654	0.098	par_21	L7--Lean

When reviewing Table 7, it illustrates that there are different variables needing special attention, such as S4, S5 (construct S), L2, L3 and L7 (construct L), due to low levels of estimates values and occurrence probability (gray highlighted in Table 7). Similar variables could negatively affect the company's performance being studied. The improvement of these variables allows a holistic integration among these constructs and strengthens bidirectional effect of lean along SCM and OP.

CONCLUSIONS

This paper intended to show that SCM could improve performance, through the mediation effect of lean from HPM perspective, based on the impact that lean has on efficiency, competitive advantage, and organization performance. Inter-related practices of lean from several programs (JIT, TPM, TQM, HR,), SCM and OP are proposed and discussed. These are important in competitiveness settings and in other operations and supply settings characterized by lean mediation. Moreover, we found an evidence of cross-sectional partial mediation, showing a bidirectional synergetic relationship between both programs toward higher performance. Besides, this empirical research shows some paths between three constructs, which were positively significant. This bidirectional synergistic relationship, means that lean increases efficiency, reduces waste and time, optimizes resources in both effect measured. At the same

time, results of Table 7 show that SCM returns integration between suppliers, customer and who guides customer relationship, having significant direct effect on operational performance. Also, the practical meaning of bidirectional synergetic relationship is reached when companies go beyond internal activities of their organization, focused on suppliers and distributors, the focus on lean implementation and research had been within shop floor or core process of single organizations, not extending to whole supply chain. At the same time, different companies found that it was not enough to improve performance only within organizations. The improvement must be extended across the entire supply chain. Considering synergetic relationship between SCM, L and OP, lean as a management approach has been projected by many researchers to make supply chain management more effective. Also, lean can have described as a close alignment from raw material to customer through cooperation. Thus, lean management can be adopted by organizations seeking to integrate their supply chain members and activities.

Several important contributions can be drawn from this research. First, the main contribution of this study is that it reconsiders the way that lean construct has been treated in the POM literature and takes an extended discussion of its holistic notion by JIT, HR, TPM, and TQM. In addition, this empirical study presents an approach to evaluate lean mediation using SEM and PLS customized to operation management. Furthermore, it tries to show competitive advantage of lean mediation for a more effective SCM. At the same time, strengthening of variables of three constructs shown in Table 7, has a positive effect on the company's performance and their competitiveness. This allows managers to have several options to take a more effective decision about a real integration of both programs and their practices, by considering bidirectional synergetic relationship in question from a view of operations and supply, more attuned to demands of plants worldwide.

Mediation between two constructs can be influenced by internal variables of each constructs that does not have significant correlation, giving way to a partial mediation and to finding of those aspect or issues that needed change or that not should be considered into measuring. Second, organization performance can be optimized when organization considered all different issues, which are measured in HPM program, as important as suppliers, trading partners, etc. Third, to have a complete or holistic vision about the main problem of this research it will be necessary a complete measure of all variables around the constructs. This will increase reliability and data significance, finding variables that need to improve in each construct to have a positive correlation and more integration, thus giving space where lean mediation could function totally in bidirectional way. Hence, more research is needed before this conclusion can be generalized to other countries or regions.

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